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DEPTH AND SPATIAL DISTRIBUTION OF BLUE WHITING JUVENILES IN BAY OF BISCAY

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ABSTRACT

During March-April 1994 and 1996 two cruises have been performed around Bay of Biscay in order to check movements of blue whiting using acoustic methods. These cruises consisted in a double coverage of an area from 47°30' N, 7°15' W to 43°30' N, 6°30' W along the French and Spanish continental shelf-break (200 m to 1000 m).

During these surveys juveniles of blue whiting were found in off-shore pelagic schools. This paper describes the spatial distribution and depth of these schools around the studied area.

INTRODUCTION

A general problem in acoustic is the identification of echotraces. When an acoustic survey is performed, the most common method for echo identification and echo allocation in both species and length composition is to take biological sampling (Johannesson and Mitson, 1983; MacLennan and Simmonds, 1991). These samples are normally taken along the covered area using different methods, being pelagic trawl hauls the most usual for pelagic species. In spite the problems of availability, accesibility and catchability that present the pelagic gears (Anon, 1996), this method is still the most recommended. A general rule during the acoustic surveys is to perform fishing samples on known echotraces in order to determine size composition and/or age composition among other biological details and combining these fishing samples to those conducted for identify unknown echotraces.

During the acoustic surveys progammend by the IEO to study the movements of blue whiting along the Bay of Biscay, an important proportion of fishing samples carried out in French waters were conducted to identify the different echotraces found in this area. The fishing stations allowed blue whiting echotraces be identify since these echotraces were slightly

different to those found in the Spanish area. In addition, some fishing stations gave a size compositons of blue whiting which they were never recorded during the previous Spanish acoustic surveys, from 1991 to 1993. These sizes corresponded to juvenile fraction, below 14 cm as a mean length.

This paper describes the size distirbution of these fishing samples as well as the structure and spatial distribution of echotraces.

MATERIAL AND METHODS

The cruises were carried out in 1994 and in 1996 on board R/V "Cornide de Saavedra". The main objective for these surveys was the study of the movements of blue whiting adults around Bay of Biscay during the spawning season, in spring 1994, from 15th March to 14th April (SEFOS 0394), and in 1996 from 11th March to 13th April.

The survey grids were designed to provide the best coverage on the main area blue whiting could be found. In SEFOS 0394 the survey grid consisted of a zig-zag track design with 20 nautical miles between peaks, with random start, whereas a parallel track design with 24 nmi between transects was performed in SEFOS 0396, from 41°50' N , 9°38'W (north Atlantic coast of Spain) to 47°40'N, 7°W (French Brittany coast). The main transect direction, in both cases, was normal to the isobath contour, over the shelf break. In addition, in SEFOS 0396, in the Spanish area, extra transects were allocated in order to evaluate the Spanish fraction of sardine. The distance between transects varied between 12 nmi as a general distance and 6 nmi in specific areas. To test the blue whiting movements, an area comprehended between 46°30'N in French waters and 6°30'W the Spanish waters was covered twice in both survey (Figure 1)s.

A Simrad EK-500 echointegrator with a 38kHz split beam transducer was used. In 1994, due to bad weather conditions, it was not possible to calibrate this equipment and the results of the previous calibration (November 93) were assumed. In 1996 the calibration was performed before the survey. Both surveys were conducted day and night at a ship speed of 10 knots. Integrated values were directly collected every nautical mile and stored in a PC, which controlled the main seatings of the echosounder. Geographical position was also taken by GPS.

Fishing stations were carried out using two different pelagic gears. In SEFOS 0394 a pelagic gear of 12 m vertical opening was used whereas in SEFOS 0396 the vertical opening was 22 m. Both gears had a codend with meshes of 22 mm. A Simrad FR 500 net sonder and Süberkrüp otter boards were also used.

Density maps over S_a values (Bodholt, 1990) of juvenile were produced, when possible, using the kriging method implemented in SURFER v6.0 (Golden software, Inc). The analysis of spatial structure and the fitted models for experimental variograms were performed using EVA v 1.0 (Petitgas and Prampart, 1993).

RESULTS

During the first coverage of SEFOS 0394 juveniles were found at the inner of Bay of Biscay (between 3°20'W and 1°55'W to 45°25'N), over an area limited by the 200 m isobath and spreading offshore untill 2000 m isobath more o less. Two pelagic trawl hauls were conducted in this area at 43°42'N-2°44'W and 43°48'N-2°17'W. In both blue whiting juveniles have been found with jellyfish, being more important the quantity of jellyfish during the second haul (82.5% in weight of total catch with a total of 406 blue whiting juveniles) whereas in the first the proportion of juveniles caught was 83% of total catch (3231 specimens). Length range for the first haul was 27 to 49 mm, with 35.59 mm as mean and 17.45 as standard deviation; for the second range was 35 to 62 mm, with 48.48 mm as mean and 17.40 mm as standard deviation (Figure 2,Table 1).

Juveniles have been found aggregated in large schools and in a small patches, with spatial continuity, very close to the sea surface, between 10 to 75 m depth. This spatial distribution allowed variogram be performed over its distribution area. To construct this variogram, a total of 139 positive data were used. 11 samples gave S_a higher than 1000 m^2/nmi^2, which had a contribution of 57% of total variance and 22.9% of mean. The highest values were located at the western part of the area and variograms performed over different directions showed anisotropies, which dissappeared when log transformation over raw data was done. Using the spatial structure found with this transformation, experimental variogram performed over raw data was fitted to a spherical model with sill of 78000, range of 8 nmi and 55000 as a nugget effect and the resulted kriging map is shown in figure 3.

During the second coverage of SEFOS 0396 juveniles of the same size have been found in almost the same area. In this case, only a few specimen were caught and the echotraces were also scarces.

Juveniles of higher size were also found during the second coverage of SEFOS 0394. They were located further north, around 46°N and 5° in waters deeper than 500 m. A fish station was performed at 46°48'N and 5°42'W. A total of 816 blue whiting were caught, being almost 100% of total catch (only two specimens of jellyfish and one *Capros aper* and one *Maurolicus muelleri* were also caught). Length range was from 9 to 11 cm with a mean of 10.7 cm and standard deviation of 0.58 (Figure 4, Table 1).

Fish were distributed in a continuous layer around 150 m depth, which spreaded in a zig zag way. The highest S_a values were located at deeper waters (1000 m) and no spatial structure has been found. Nevertheless and for presentation purposes, a krigging map was performed with a spherical model with a sill of 100000, range of 5 nmi and a nugget effect of 130000, which it is shown in Figure 5.

Finally, during the first coverage of SEFOS 0396 juveniles of about 15 cm were also found at the inner part of Bay of Biscay. Two fishing station were carried out on this area. The first one was performed at 43°35'N and 2°23'W; mean depth was 600 m and the pelagic year was trawled at 130 m depth. A total of 673 specimen were caught (100% of total catch) with a range of 13-16 cm and 14.63 cm as a mean and standard deviation of 0.75. The other station was performed over the continental shelf at 43°25'N and 2°23'W and at 130 m depth. Again, 100% of total catch was blue whiting (435 specimens), with 14.99 cm as a mean length (13-

16 cm range) and a standard deviation of 0.91 (Figure 6, table 1). The juveniles which have been found offshore, formed large and thick pelagic schools, similar to those found for the juveniles of 4-6 cm but 100 m deeper and clearly different to the zig-zag layer formed by the juveniles of 11 cm. Moreover, these schools were found close to the shelf break and no jellyfish have been caught.

DISCUSSION

The Bay of Biscay has been described as a retention area for both blue whiting larvae and post larvae. Schmidt (1909) found in this area specimens of 3-7 cm in May and Maucorps (1979) has reported the presence of juveniles of 7 cm in the same month and area. Nevertheless, juveniles have been normaly reported for northernmore areas, which were compiled by Bailey (1982). This records took generally place in midsummer around Faroes Islands and Iceland. Our records were ealier than those described above. Both sizes, 4 and 10 cm length, aggree with the reported larval growth and spawning season along the European waters (Bailey, 1982), and possibly, 9 cm length juveniles came from an earlier spawning period (e.g. winter) whereas juvenile of 4 cm might correspond to post-metamorphosis specimens. During April 1994 an important southwards thermohaline front was detected at the inner part of Bay of Biscay, which could explain the large concentration in this area of juveniles coming from nothern areas (Porteiro *et al.*, 1996).

On the other hand, the presence of speciemens of 14 cm length is not usual at this time. They have been routinely reported during the Spanish Bottom Trawl Surveys which are carried out in September-October (Sánchez, 1992, 1993, 1994). Besides, the Spanish acoustic surveys carried out in spring of 1991-94 have always reported specimens higher than 15 cm. In this case, probably the spawning season started earlier than previous years as it was suggested in Carrera *et al.* (1996)

The presence of juvenile together with jellyfish could be explained by means of drift and transport processes that took place in the inner part of Bay of Biscay and by the predator-prey relationship between these species. In fact, jellyfish are described as important predators of larval fish (Bailey, 1984; de Lafontaine and Leggett, 1987) and these macrozooplankters could be transported as well as larvae and post-metamorphosis fish to the retention areas where they remain.

The most noticeable feature is the different shape of schools, depth and area that present the juvenile in relation to their size. Whereas the smallest were found clearly offshore and close to the sea surface and showing an aggregative distribution in patches, juveniles of 10 cm remained close to the shelf break and a deeper waters (between 100-150 m) than those; in addition, they seemed to have a contagious distribution in a ribbon-like echotrace as described in Bailey (1982). Both sizes seems to be clearly pelagic, without relation to the sea bed and, even more, without relation to the continental shelf. On the other hand, juveniles of 14 cm can be found either close to the sea bed, over the continental shelf, or in pelagic schools at 150 m depth. Adults can be also found close to the bottom or pelagic; in this case, and at least in the studied area, they form a continuous layer as the juveniles of 10 cm, and which depth distribution is normally around 250-350 m.

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Date	Time	Position Lat-Lon	Depth Bot-Trawl	Catch (Kg)	% Weight	No	Samp	Range	Mean (sd)
25/3/94	10:00	43°42'-2°44'	1600-30	1.3	83	3231	164	27-49	35.6 (17.5)
25/3/94	14:30	43°48'-2°17'	750-30	2.1	17.5	406	206	35-62	48.5 (17.4)
19/4/94	12:30	46°48'-5°42'	2200-130	5.6	100	816	81	9-11	10.7 (0.58)
24/3/96	14:30	43°34'-2°28'	800-130	43.7	100	673	80	13-16	14.6 (0.75)
24/3/96	22:30	43°28'-2°23'	140-130	6.6	100	435	80	13-16	14.9 (0.91)

Table 1: Main features of the fishing stations: date, time, mean position -latitude, longitude-, bottom depth and trawling depth, total catch (Kg), percentage in weight of blue whiting caught, total number of blue whitng, sampling, length range and mean length and its standard deviation (cm) of blue whiting. First two station have range and mean length expresed in mm.

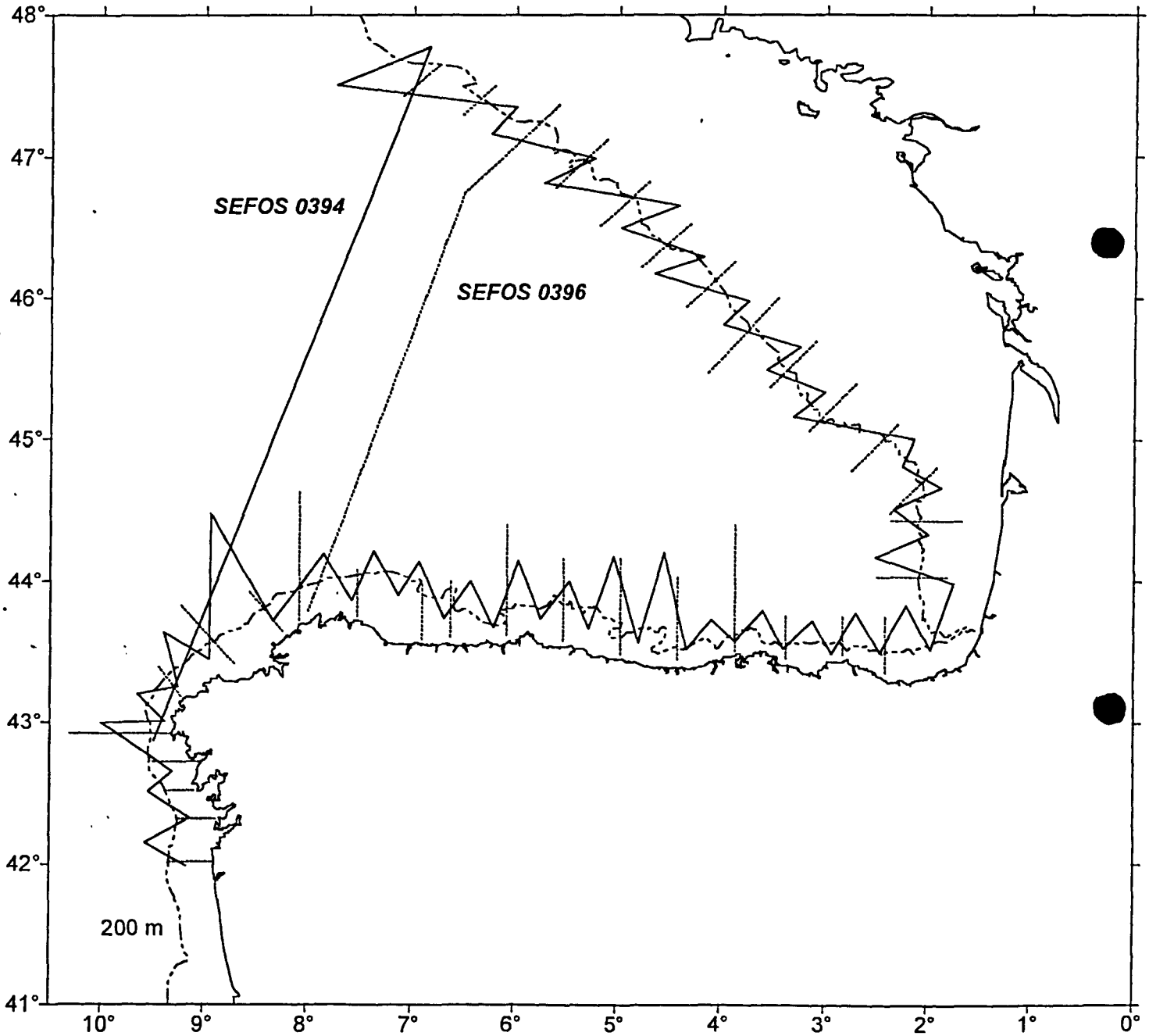

Figure 1: Acoustic tracks during SEFOS 0394 (continuous line)and SEFOS 0396 (dotted line) surveys

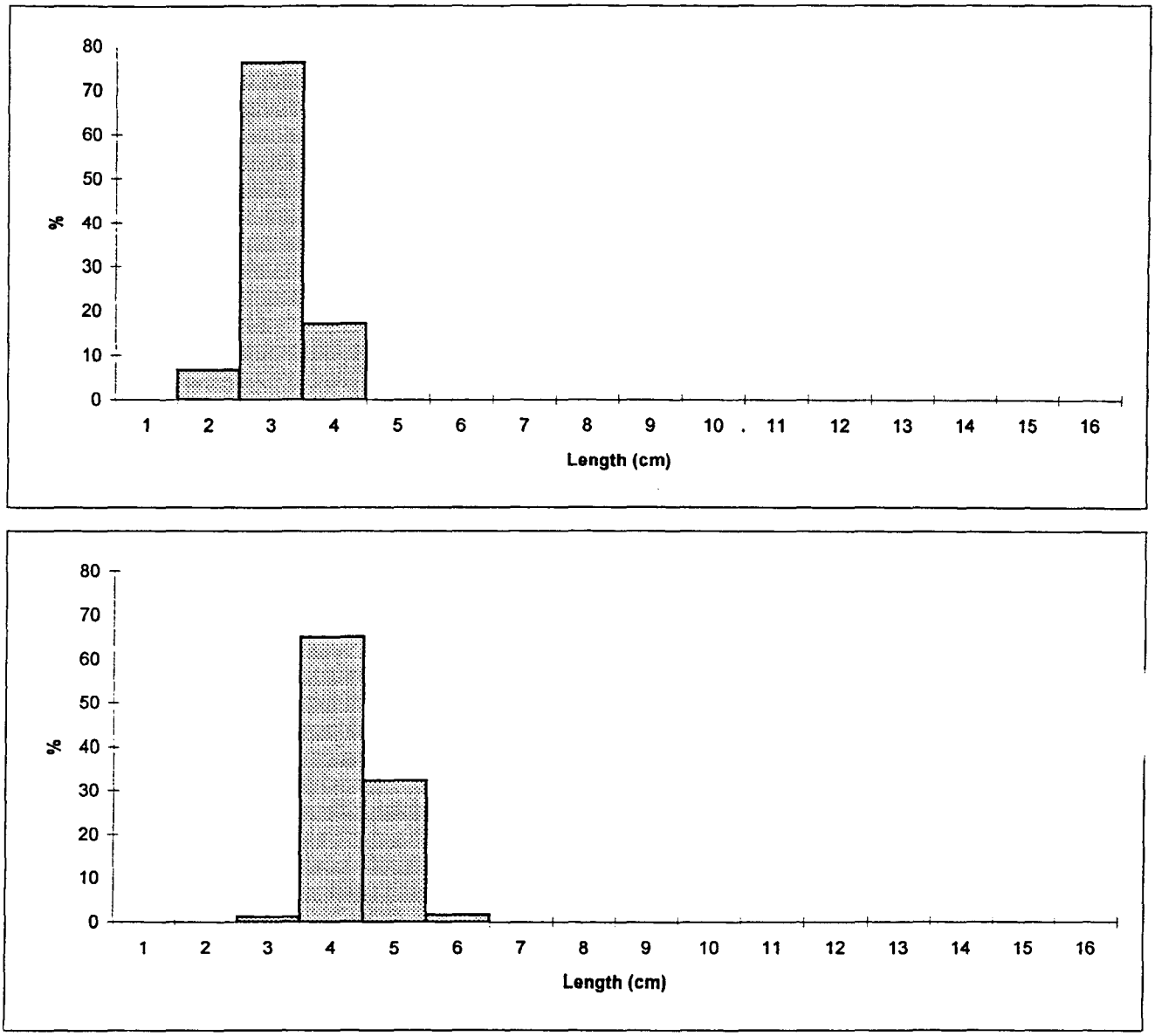

Figure 2: Length distribution for blue whiting juveniles of mean length of 3.56 cm (above) and 4.85 cm (below)

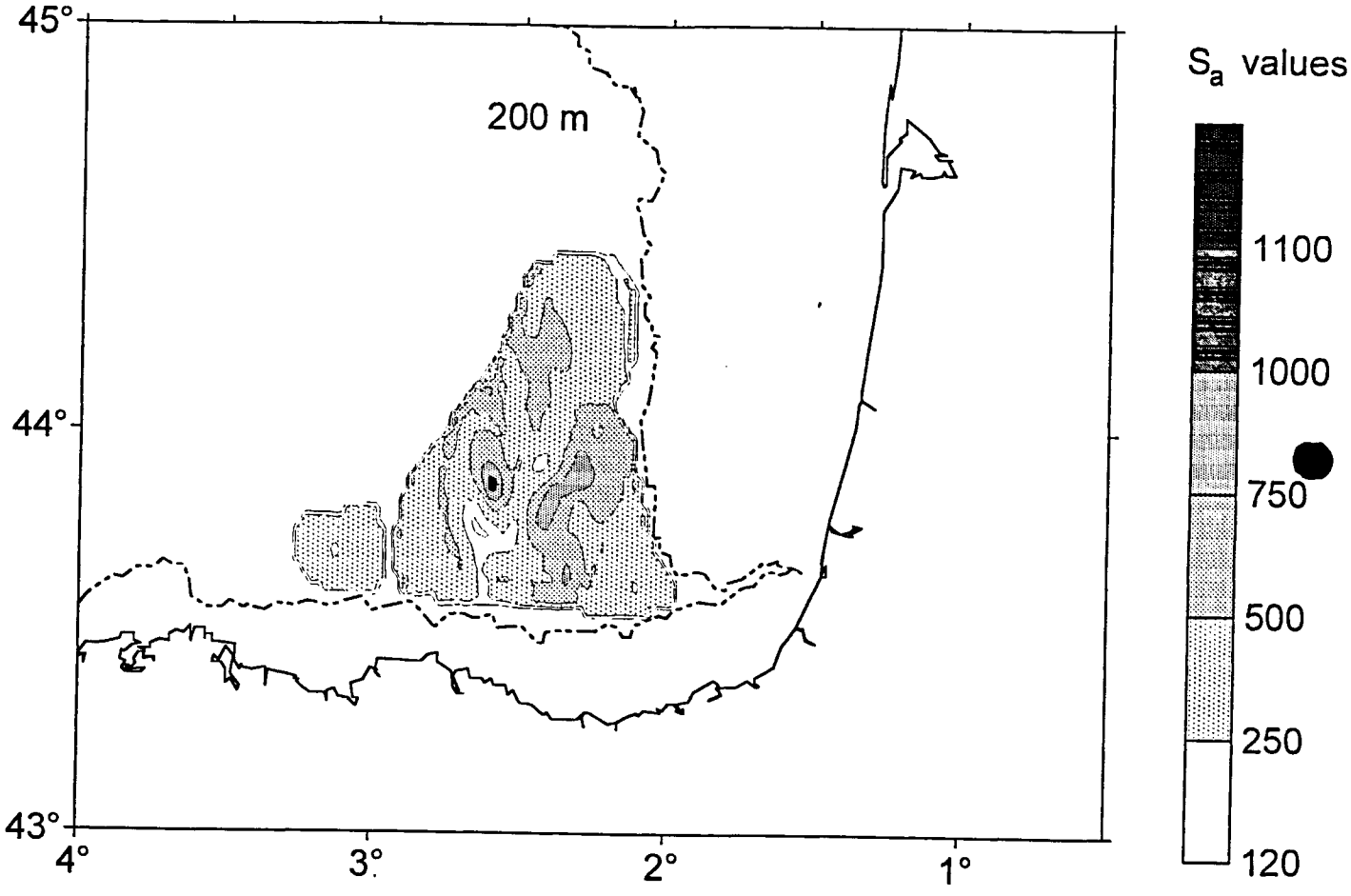

Figure 3: Spatial distribution of juvenile blue whiting (length < 6.5 cm) found during SEFOS 0394 survey.

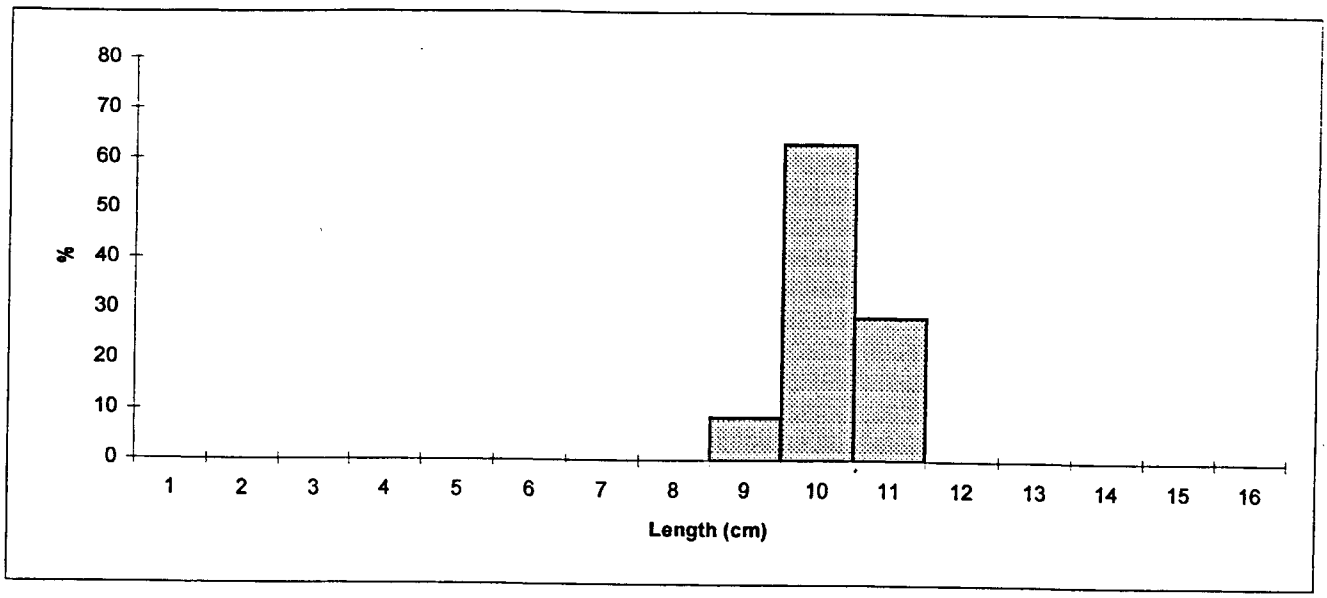

Figure 4: Length distribution for blue whiting juveniles of mean length of 10.7 cm

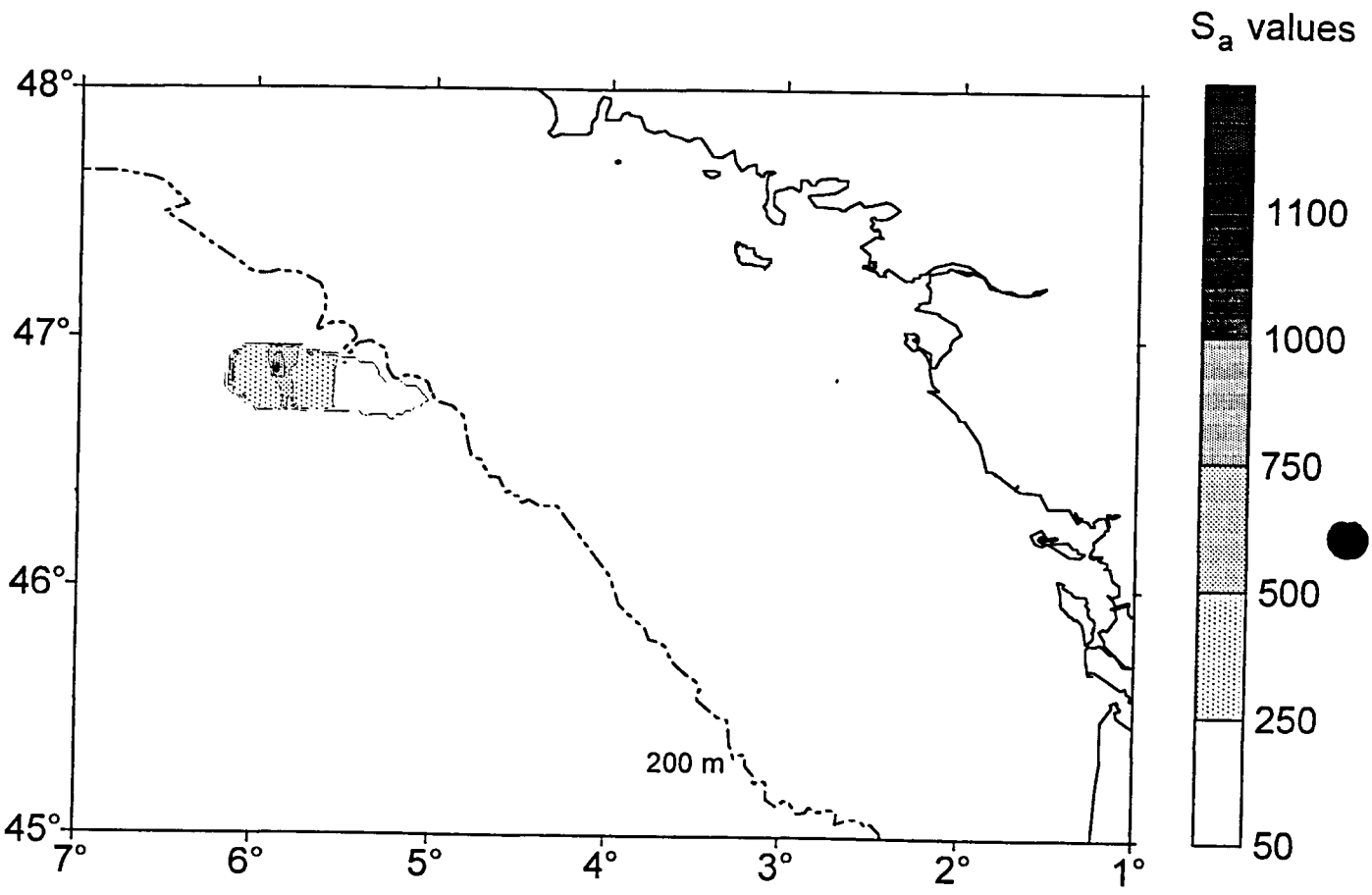

Figure 5: Spatial distribution of juvenile blue whiting (mean length = 10.7 cm) found during SEFOS 0394 surv

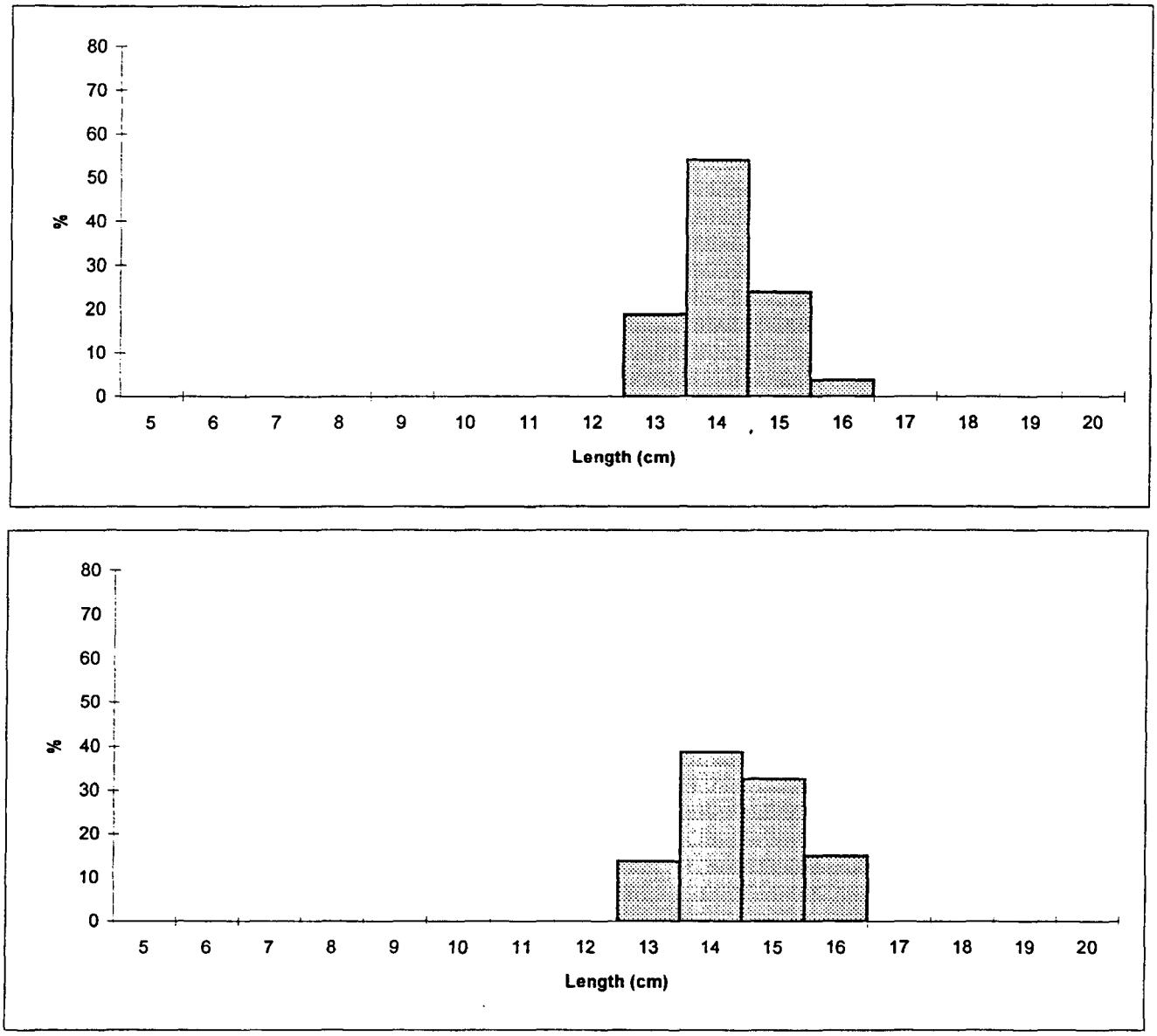

Figure 6: Length distribution for blue whiting juveniles of mean length of 14.6 cm (above) and 14.9 cm (below)